ONTARIO MINISTRY OF ENVIRONMENT
36936000021120

TERRESTRIAL and ATMOSPHERIC DEPOSITION STUDIES

near the

ONTARIO HYDRO THERMAL GENERATING STATION, ATIKOKAN, 1992

Environment Ontario
Laboratory Library
125 Resources Rd.
Etobicoke, Ontario M9P 3V6
Canada

D. J. Racette
Environmental Scientist

H. D. Griffin
Chief, Air Quality Assessment

TECHNICAL SUPPORT SECTION
NORTHERN ONTARIO REGION
MINISTRY OF ENVIRONMENT AND ENERGY
February, 1994

TD
195
.G46
R33
1992
MOE

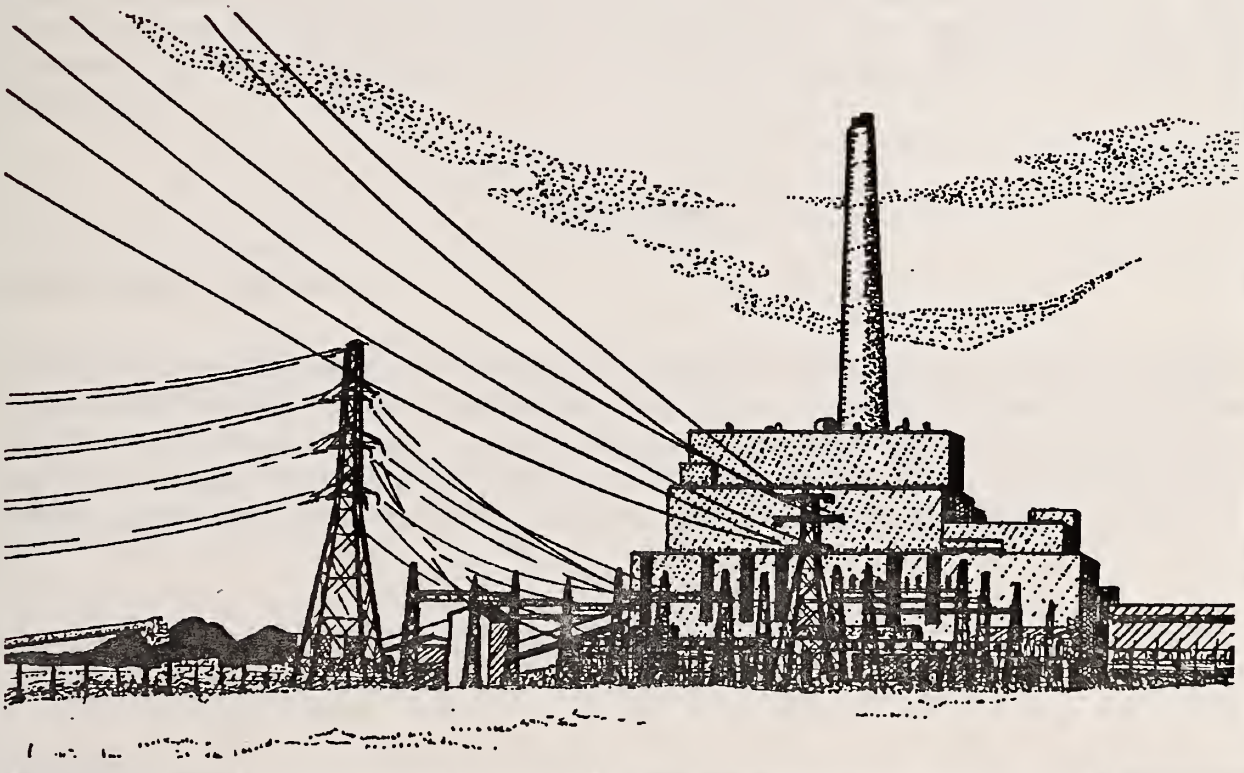
4/01/94
atikokan.txt

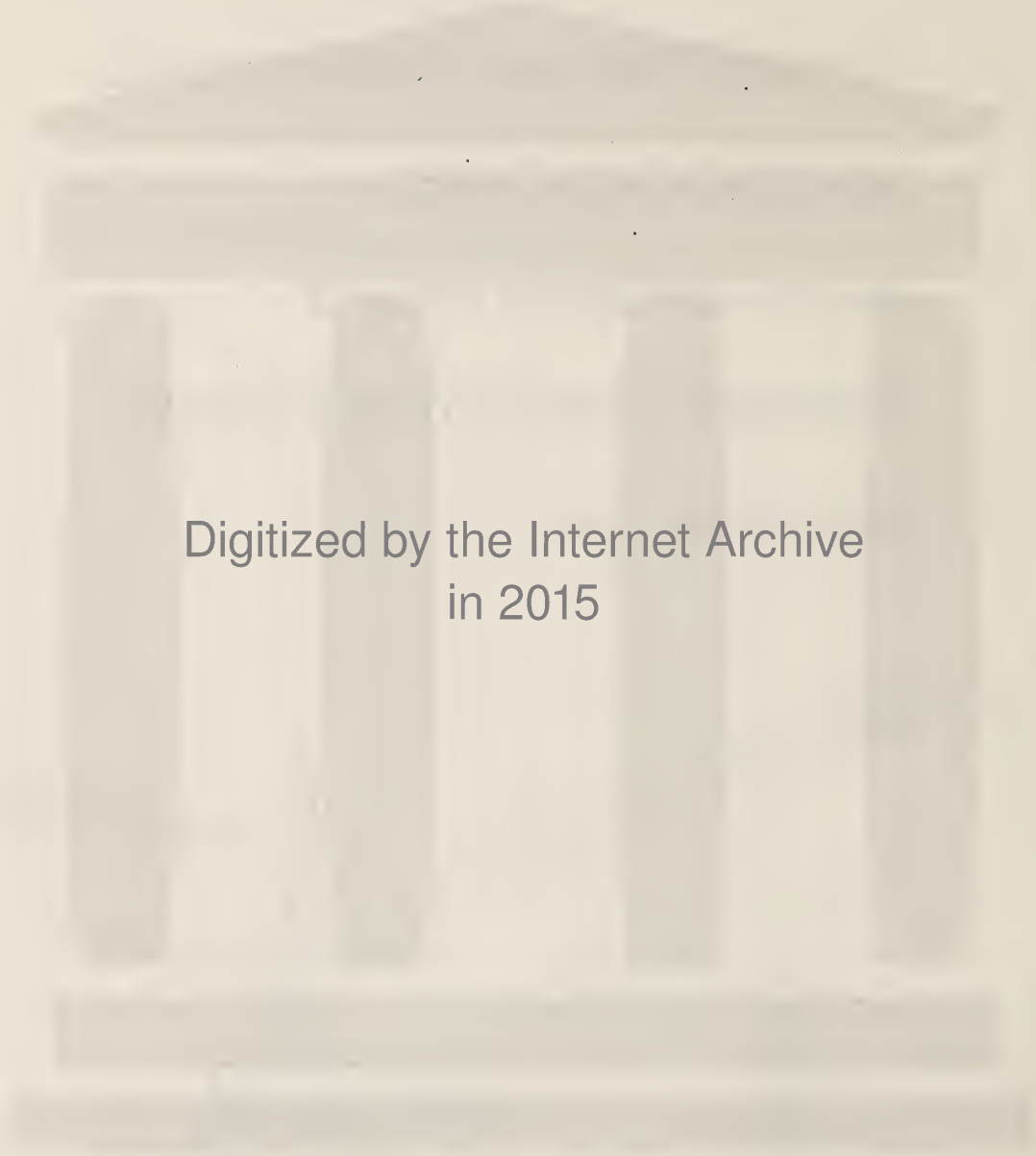
TD
195
.G46
R33
1992

Terrestrial and atmospheric deposition studies near the Ontario Hydro thermal generating station, Atikokan,

82444

TERRESTRIAL and ATMOSPHERIC DEPOSITION STUDIES near the ONTARIO HYDRO THERMAL GENERATING STATION, ATIKOKAN, 1992.





Digitized by the Internet Archive
in 2015

https://archive.org/details/terrestrialandatrace21120

INTRODUCTION

In 1979, the Ministry of Environment and Energy became part of a group to monitor the environmental effects of a thermal generating station near the town of Atikokan in northwestern Ontario. Each member of the group, comprising Ontario Hydro, Ministry of Natural Resources, and Ministry of Environment and Energy (MOEE), was responsible for different parts of the program. The MOEE component included terrestrial and atmospheric deposition studies to assess the effects of airborne emissions from the power plant. Concerns had been expressed that such effects might impact not only the local environment, but also more distant, ecologically sensitive areas such as Quetico Provincial Park in Ontario, and the Boundary Waters Canoe Area and Voyageurs National Park in Minnesota.

Ontario Hydro began construction of the generating station in 1978 and it was commissioned in late 1985. The plant is a single, 200-megawatt unit fuelled with low-sulphur lignite from western Canada. The unit currently operates infrequently, during peak demand periods. During 1992, the generating station operated about 36 percent of the time, mainly during winter months. In the 1992 growing season, power was generated on only six days.

MOEE terrestrial and atmospheric deposition studies at Atikokan began in 1981. Reports to date have shown that elevated levels of iron and arsenic occurred near the power plant in soil and in some types of vegetation.[1,2,3,4,5] Air emissions from two former iron ore pelletizing plants nearby caused this contamination.

Under the agreed monitoring plan, MOEE carried out terrestrial sampling in 1992. This report presents a summary of results from this work and from atmospheric deposition monitoring for the period 1989 to 1991. Data from previous years are included for comparison.

METHODS

TERRESTRIAL STUDIES

Study sites in 1992 (Figure 1) were the same as those for previous surveys. Where available, samples were collected of white birch foliage, and of current and one-year-old white pine needles. Feather moss (*Pleurozium schreberi*) and a foliose lichen (*Umbilicaria muhlenbergii*) were also obtained. The 1992 survey includes a smaller number of vegetation species than earlier surveys, because we felt that a reduced number could adequately show trends.

Bark was sampled at a height of 1 to 1½ m (metres) above the ground from stems of white pine trees sampled for needles. Soil from three depths (0-1, 1-2, and 2-5 centimetres) was also collected from all sites.

Standard Ministry procedures were followed in the collection and processing of soil and vegetation samples.[6] All vegetation and bark samples were analyzed for aluminum, arsenic, cadmium, chloride, chromium, copper, fluoride, iron, lead, mercury, manganese, nickel, selenium, sodium, sulphur and zinc at Ministry laboratories in Toronto and Thunder Bay. In addition to the foregoing analyses, soil was analyzed for calcium, organic matter, magnesium, phosphorus and potassium. Soil and bark pH were also determined.

Vegetation in the vicinity of sampling sites was examined for visible evidence of stress caused by disease, insects, contaminants, air pollutants and physiological factors.

Isopleths depicting areas of equal metal concentrations were calculated using SURFER software.[7] Contaminant guidelines developed by the Ministry were used to interpret the data.[8] These guidelines are based on the upper limit of normal concentrations of selected parameters in vegetation and soil in Ontario. Values above guidelines may indicate contamination problems. Exceedences do not violate Ministry regulations, nor do they necessarily imply health or environmental effects.

ATMOSPHERIC DEPOSITION STUDIES

As part of the Acidic Precipitation in Ontario Study (APIOS), MOEE operated deposition monitoring equipment at Quetico Centre (30 km east-southeast of the generating station), at Lac La Croix (70 km southwest), at Fernberg Road in northern Minnesota (95 km south) and at Forbes Township (135 km east) (see Figure 2). The Forbes Township site (re-located to Dawson township in late 1986) served as control for comparison with data from the other three sites. Cumulative (28-day) precipitation and daily precipitation sampling began at some of these sites in 1980. Description of the network and monitoring methods are reported elsewhere.[9,10]

RESULTS

TERRESTRIAL STUDIES

Tree Foliage

Insect damage to vegetation in the study area was generally minor in 1992. No visible symptoms were noted of air pollution injury to vegetation.

Chemical analysis results are presented in Table 1. No Ministry contaminant guideline exceedences were recorded in 1992. Occasional minor exceedences of some parameters occurred in previous years; none of these were attributed to emissions from Ontario Hydro.

Table 2 summarizes average elemental concentrations in coniferous and deciduous tree foliage from 1981 to 1992. Although all concentrations for this period were within the normal range, there is a trend of decreasing arsenic and iron levels over time.

White Pine Bark, Moss and Lichens

Chemical analysis summaries for 1992 are presented in Table 1. Table 2 shows average chemical concentrations from 1981 to 1992. Except for arsenic and iron, element levels in white pine bark, feather moss (*Pleurozium schreberi*) and lichen (*Umbilicaria muhlenbergii*) did not change significantly during the 12-year period. Arsenic and iron declined steadily, but were still above normal at some sites in 1992 (usually sites 1, 4 and 11). The 12-year trend is shown in Figures 3a, 3b and 3c and in Table 3 for arsenic in feather moss. A similar trend (Table 4) and distribution pattern occurred for arsenic and iron in white pine.

From 1981 to 1992, the average concentration of arsenic declined by 70 to 90 percent in white pine bark, feather moss and the lichen *Umbilicaria muhlenbergii*. In the same substrates, iron decreased almost as much (50 to 70 percent). This decrease occurred independent of the operation of the generating station.

Soil

Chemical analysis results for 1992 are presented in Table 5. As in previous surveys, arsenic and iron concentrations were elevated. These two elements were usually highest in surface soil, and decreased with increasing soil depth and increasing distance from the two former iron ore plants. Although sampling depths in these studies differed from the standard sampling depth of 0-5 cm used to interpret Ontario contaminant guidelines, the data indicate that the guideline for arsenic would have been exceeded at sites 1, 2, 3, 4, 8 and 11 in 1992.

Table 6 presents the mean concentrations of parameters in soil since sampling began in 1981. Except for arsenic in surface soil, levels of most parameters did not show a consistent pattern of increase or decrease. Aside from arsenic and mercury, all average elemental values were below current Ministry guidelines. As previously reported,[1,2,3,4,5] mercury levels were higher than expected. There were no significant relationships between mercury concentrations and distance from the generating station or from the former iron ore mines.

ATMOSPHERIC DEPOSITION STUDIES

Precipitation

Precipitation data are presented in Table 7. Precipitation chemistry and wet deposition rates were similar at all four sites throughout the 12-year study except for sulphate at Dawson Township in 1987. Wet sulphate deposition was well below the threshold (10-12 kilograms per hectare per year) above which sensitive aquatic systems might be affected. Deposition monitoring at Quetico Center, Fernberg Road, Lac La Croix and Dawson Township ceased between 1990 and 1992.

DISCUSSION

Results of the 1992 terrestrial survey at Atikokan confirmed the continued presence of elevated arsenic and iron in surface soils, lichens, mosses and white pine bark at sampling sites near the generating station. These elevated concentrations resulted from air emissions from two former iron ore mines which operated in the area for about 15 years. The steady decline in arsenic and iron concentrations from 1981 to 1992 indicated that Ontario Hydro operations had no impact on local arsenic and iron levels.

Snow, soil and vegetation sampling surveys, and moss exposure studies have shown that atmospheric concentrations of all measured parameters did not increase during the operational phase of the generating station (1986-1992), compared to the pre-operational phase (1981-1985). Except for arsenic and iron, levels of all parameters studied were usually within normal background ranges throughout the 12-year study period.

Mercury levels in the soil surface were higher than expected, both during operational and pre-operational periods. The reason for this is unknown, but may be ascribed to natural causes or to fallout from long-range atmospheric transport; local point sources are not implicated.

This report concludes the Ministry's study of effects of air emissions from the Atikokan generating station on the surrounding terrestrial environment and on precipitation chemistry. No further sampling is planned at this time.

CONCLUSIONS

1. Terrestrial monitoring and atmospheric deposition studies have not detected any measurable impact from the Atikokan generating station on the surrounding environment.

2. Elevated arsenic and iron in surface soils, feather moss and white pine bark were caused by emissions from two former iron mines.

3. Arsenic and iron levels in soil and vegetation decreased substantially from 1981 to 1992.

REFERENCES

1. Racette, D. J. and H. D. Griffin. 1991. Terrestrial and atmospheric deposition studies near the Ontario Hydro thermal generating station, Atikokan, 1987-1989. Ontario Ministry of the Environment.

2. Racette, D. J. and H. D. Griffin. 1989. Terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1986. Ontario Ministry of the Environment.

3. Racette, D. J. and H. D. Griffin. 1985. Air quality studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1983. Ontario Ministry of the Environment.

4. Racette, D. J. and H. D. Griffin. 1984. Air quality studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1982. Ontario Ministry of the Environment.

5. Racette, D. J. and H. D. Griffin. 1984. Air quality studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1981. Ontario Ministry of the Environment.

6. Ontario Ministry of the Environment. 1983. Field investigation procedures manual. Phytotoxicology Section, Air Resources Branch.

7. Golden Software, Inc. 1991. SURFER. Version 4.01. Golden Software, Inc., P.O. Box 281, Golden, Colorado, 80402, U.S.A.

8. Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment 'upper limit of normal' contaminant guidelines for phytotoxicology samples. Phytotoxicology Section, Air Resources Branch.

9. Chan, W. H., Orr, D. B., Bardswick, W. S. and R. I. Vet. 1985. Acidic Precipitation in Ontario Study. An overview: The event wet/dry deposition network. Ontario Ministry of the Environment Report ARB-142-85-AQM.

10. Chan, W. H., Orr, D. B., Bardswick, W. S. and R. I. Vet. 1985. Acidic Precipitation in Ontario Study. An overview: The cumulative wet/dry deposition network (2nd revised edition). Ontario Ministry of the Environment Report ARB-141-85-AQM.

ACKNOWLEDGEMENTS

We acknowledge with thanks the assistance of staff funded by Experience '92 Program in carrying out the Atikokan vegetation and soil surveys. We also appreciate the assistance of a student from the Lakehead Board of Education's co-operative education program in preparing graphic presentations for this report.

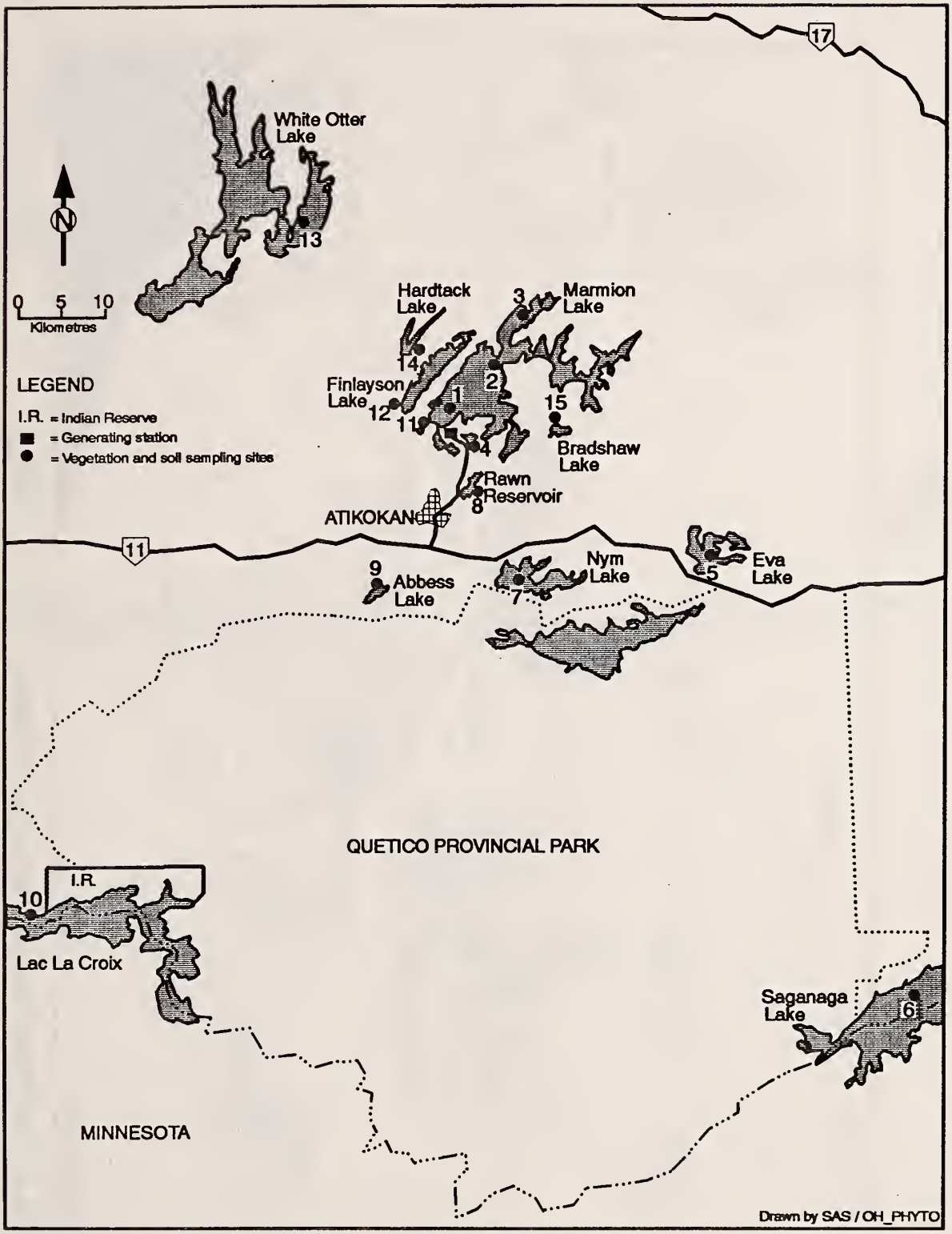


Figure 1. Soil and vegetation sampling sites, Atikokan, July 20-22, 1992.

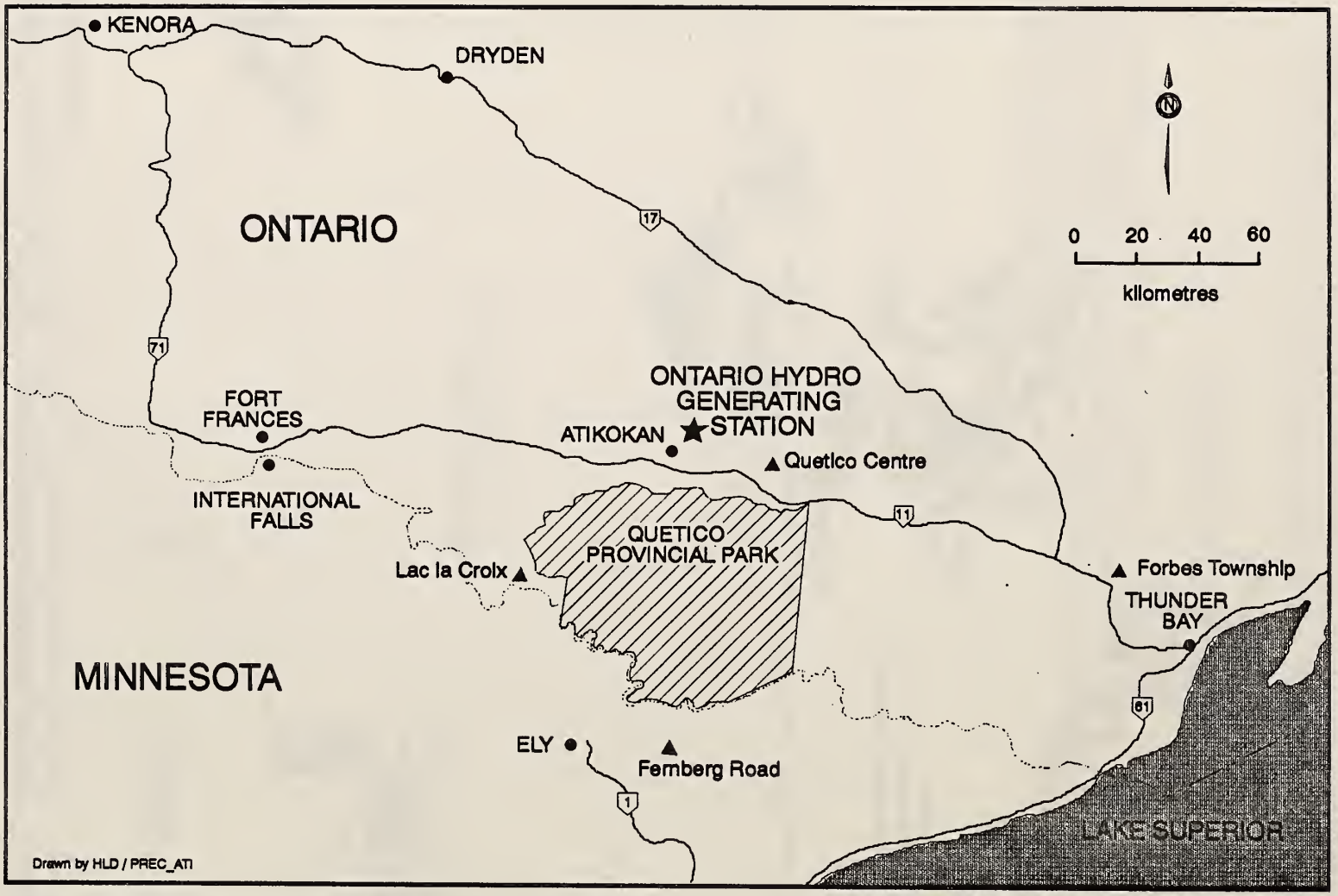


Figure 2. Precipitation sampling sites (▲), Atikokan.

Figure 3a. Average levels of arsenic (ug/g, dry weight) in *Pleurozium schreberi*, Atikokan, 1981-1983.

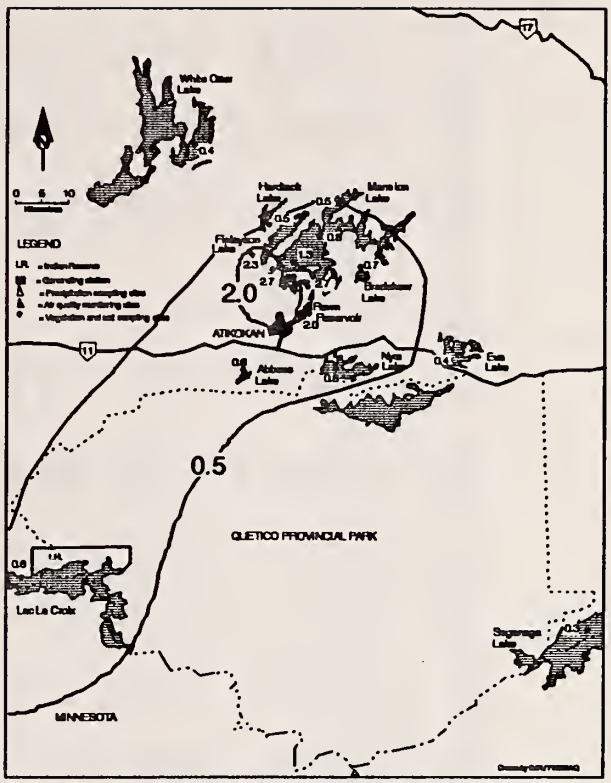


Figure 3b. Average levels of arsenic (ug/g, dry weight) in *Pleurozium schreberi*, Atikokan, 1986-1988.

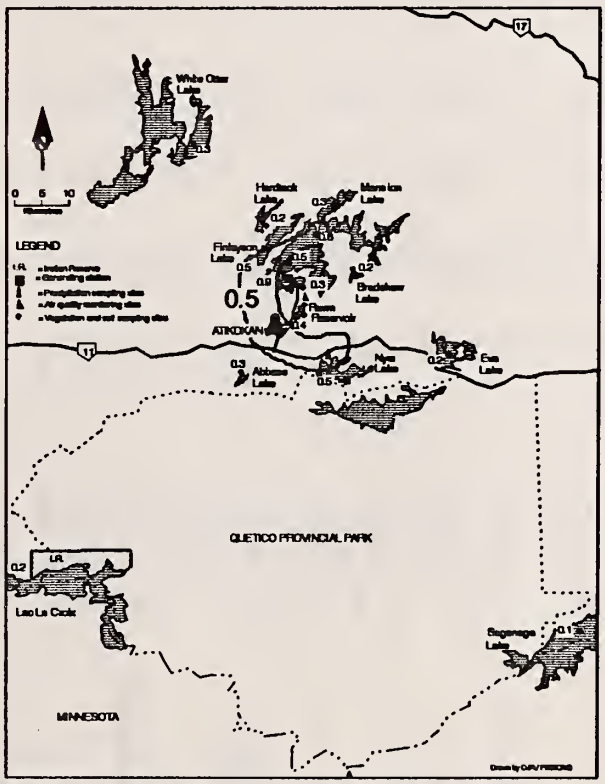


Figure 3c. Levels of arsenic (ug/g, dry weight) in *Pleurozium schreberi* Atikokan, 1992.

TABLE 1. Levels of selected elements in vegetation, Atikokan, 1992. All elements are $\mu g/g$, dry weight except chloride and sulphur, which are in percent dry weight.

Plant species		Al	As	Cd	Cl	Cr	Cu	F	Fe	Pb	Mn	Hg	Ni	Se	Na	S	Ti	Zn
White pine[a] (current)	Maximum	150	<0.1	<0.3	0.04	<1	4	0.6	35	<2	260	0.01	8	0.1	45	0.10	<1	38
	Mean	110	<0.1	<0.2	0.01	<1	3	<0.5	26	<2	140	0.01	3	<0.01	11	0.08	<1	29
	Minimum	82	<0.1	<0.2	<0.01	<1	2	<0.5	22	<2	59	0.01	2	<0.01	<10	0.03	<1	21
	Std. Dev.[b]	21	0	0.1	0	0	1	0.1	4	0	65	0.01	1	0	12	0	0	5
White pine[a] (1-year-old)	Maximum	340	0.2	0.3	0.01	<1	2	0.8	110	<2	690	0.02	4	0.2	35	0.08	2	62
	Mean	260	<0.1	<0.2	<0.01	<1	2	<0.5	79	<2	340	0.01	1	<0.01	<10	0.06	1	36
	Minimum	200	<0.1	<0.2	<0.01	<1	2	<0.5	48	<2	77	<0.01	<1	<0.01	<10	0.02	1	19
	Std. Dev.	35	0	0.1	0	0	0	0.2	23	0	220	0	1	0	8	0.01	0	12
White birch	Maximum	21	0.1	0.8	<0.01	<1	7	1.4	70	<2	1300	0.01	4	0.3	15	0.15	1	170
	Mean	14	<0.1	0.4	<0.01	<1	4	0.6	53	<2	560	<0.01	2	<0.01	<10	0.09	1	94
	Minimum	8	<0.1	0.2	<0.01	<1	2	<0.5	36	<2	130	<0.01	1	<0.01	<10	0.05	<1	25
	Std. Dev.	4	0	0.2	0	0	1	0.4	9	0	300	0	1	0.1	3	0.02	0	36
Pleurozium schreberi[a]	Maximum	1200	0.9	0.3	<0.01	2	5	4.5	1700	4	310	0.13	2	0.4	73	0.10	37	50
	Mean	780	0.4	0.2	<0.01	1	3	1.9	1100	3	220	0.08	1	0.3	30	0.08	25	32
	Minimum	500	0.1	<0.2	<0.01	<1	2	<0.5	610	2	120	0.04	<1	0.2	<10	0.06	17	18
	Std. Dev.	200	0.2	0.1	0	0	1	1.7	310	0	73	0.02	0	0.1	19	0.01	6	8
Umbilicaria muhlenbergii[a]	Maximum	1300	6.0	0.3	0.08	4	13	4.3	5000	15	87	0.12	4	1.3	80	0.12	50	88
	Mean	830	2.0	<0.2	0.01	2	3	2.0	2100	10	31	0.10	2	0.8	51	0.10	33	37
	Minimum	430	0.3	<0.2	<0.01	<1	2	<0.5	640	2	13	0.08	<1	0.4	35	0.08	17	21
	Std. Dev.	280	2.0	0.1	0.02	1	3	1.6	1500	4	20	0.01	1	0.3	16	0.02	16	19
White pine bark[a]	Maximum	750	3.8	0.5	<0.01	2	6	1.5	2500	8	150	0.15	2	0.8	35	0.04	18	39
	Mean	400	0.8	0.2	<0.01	<1	2	0.7	590	4	48	0.06	<1	0.2	<10	0.02	7	25
	Minimum	330	<0.1	<0.2	<0.01	<1	2	<0.5	140	<2	13	0.02	<1	<0.01	<10	0.01	3	8
	Std. Dev.	140	1.0	0.1	0	0	1	0.4	600	2	33	0.04	0	0.2	10	0.01	4	8
Contaminant guideline[c]		500	2.0	1.0[d]	0.15	8	20	15	500	30	3000	0.10	5	0.5	50	0.4		250[d]

[a] Contaminant guidelines do not apply
[b] Standard deviation of the mean.
[c] Applies to deciduous foliage only.
[d] Does not apply to accumulator species (birch).

jg/12/16/93
air\elements.dr

TABLE 2. Annual average concentration of selected elements in vegetation, Atikokan, 1981-1992. All results are in $\mu g/g$, dry weight, except chloride, fluoride and sulphur, which are in percent, dry weight.

Plant species	Year	Al	As	Cd	Cl	Cr	Cu	F	Fe	Pb	Mn	Hg	Ni	Se	Na	S	Zn	pH
White pine (current)	1981	150	<0.1	<0.5	<0.10	2	4	8	66	2	220	0.02	4		<25	<0.10	35	
	1982	160	<0.1	<0.5	0.01	<2	4	1	61	<3	210	<0.01	3		<25	0.09	35	
	1983	140	0.1	<0.5	0.01	<2	4	<1	81	<3	170	<0.01	2	0.1	<25	0.08	33	
	1986	160	<0.1	<0.1	0.01	<1	4	<1	35	<1	170	<0.03	3	<0.1	<20	0.09	34	
	1987	100	0.2	<0.2	<0.01	<1	<1	<1	35	<2	140	<0.03	1	0.1	29	0.09	26	
	1988	140	<0.5	<0.2	<0.01	<1	2	<1	63	<2	160	<0.01	2	<0.5	41	0.08	27	
	1992	110	<0.1	<0.2	0.01	<1	3	<1	26	<2	140	<0.01	3	<0.1	11	0.08	29	
White pine (1-yr-old)	1981	430	0.4	0.5	<0.10	3	3	7	210	<3	390	0.04	2		<25	0.10	44	
	1982	290	0.3	<0.5	0.01	<2	3	1	150	<3	370	0.02	2		<25	0.08	42	
	1983	310	0.2	<0.5	0.01	<2	3	<1	120	<3	340	0.01	<2	0.2	<25	0.08	40	
	1986	350	<0.1	0.1	0.01	2	3	<1	90	<1	400	<0.03	2	0.2	<20	0.08	44	
	1987	260	0.1	<0.2	0.01	<1	<1	<1	89	<2	320	<0.03	<1	0.2	22	0.08	35	
	1988	300	<0.5	<0.2	0.01	<1	2	<1	140	<2	370	0.02	<1	<0.5	15	0.09	31	
	1992	260	<0.1	<0.2	<0.01	<1	2	<1	79	<2	340	0.01	1	<0.1	<10	0.06	36	
White pine bark	1981	390	2.9	0.5	<0.10	2	3	11	1200	6	56	0.08	2		<25	<0.10	28	3.2
	1982	530	3.1	<0.5	<0.01	2	4	12	1400	9	53	0.09	<2		30	0.03	28	3.6
	1983	620	3.4	0.5	<0.01	2	3	6	1200	7	54	0.10	1	0.6	33	0.03	28	3.4
	1986	550	1.4	0.2	<0.01	2	3	<1	1100	5	54	0.08	1	0.3	<20	0.02	35	3.6
	1987	430	1.5	<0.2	<0.01	<1	2	<1	1200	4	42	0.07	1	0.4	13	0.02	21	

Continued ...

sm\16\12\93
tech\table2.djr

Plant species	Year	Al	As	Cd	Cl	Cr	Cu	F	Fe	Pb	Mn	Hg	Ni	Se	Na	S	Zn	pH
	1988	330	0.6	<0.2	<0.01	<1	3	4	520	4	38	0.04	<1	<0.5	14	0.03	22	
	1992	410	0.8	0.2	<0.01	<1	2	<1	590	4	48	0.06	<1	0.2	<10	0.02	25	3.6
White birch	1981	55	0.3	1.0	<0.10	<2	5	7	100	2	790	0.02	2		<25	0.10	120	
	1982	46	0.2	<0.5	0.02	<2	4	3	110	<3	710	<0.01	<2		26	0.11	96	
	1983	31	0.2	0.7	0.01	<2	5	<1	81	<3	770	<0.01	<2	0.09	<25	0.10	130	
	1986	37	<0.1	0.4	<0.01	4	5	<1	66	<1	740	<0.03	3	0.17	<20	0.11	100	
	1987	51	0.2	0.4	<0.01	<1	2	3	78	<2	540	<0.03	<1	0.19	32	0.11	74	
	1988	51	<0.5	0.2	<0.01	<1	3	<1	84	<2	560	<0.01	<1	<0.50	39	0.11	79	
	1992	14	<0.1	0.4	<0.01	<1	4	<1	53	<2	560	<0.01	2	<0.10	<10	0.09	94	
Pleurozium schreberi	1981	960	4.5	0.8	<0.10	5	6	14	3000	15	280	0.10	2		41	0.10	31	
	1982	980	4.4	<0.5	<0.01	6	5	2	3000	15	230	0.09	<2		50	0.09	35	
	1983	850	2.6	<0.5	<0.01	3	4	<1	2000	14	210	0.08	<2	0.51	31	0.07	31	
	1986	1200	2.2	0.3	<0.01	6	4	<1	2700	10	300	0.10	3	0.50	36	0.07	35	
	1987	840	0.7	0.2	<0.01	1	3	<1	1100	6	210	0.07	1	0.37	53	0.07	28	
	1988	840	0.5	0.2	<0.01	1	3	2	1000	5	210	0.06	<1	<0.50	54	0.07	26	
	1992	780	0.4	0.2	<0.01	1	3	2	1100	3	220	0.08	1	0.28	30	0.08	32	
Umbilicaria muhlenbergii	1981	990	8	0.6	<0.10	5	5	15	4400	24	35	0.16	3		55	0.14	37	
	1982	1100	5	<0.5	0.03	5	5	1	3300	23	30	0.14	3		87	0.15	32	
	1983	1000	5	<0.5	<0.01	6	3	<1	3000	21	30	0.13	<2	1.27	39	0.11	30	
	1986	1100	4	0.1	<0.01	4	4	<1	2800	19	34	0.12	3	1.34	41	0.10	33	
	1987	1400	3	<0.2	<0.01	3	3	<1	3900	18	42	0.09	2	0.98	81	0.09	31	
	1988	1000	3	<0.2	<0.01	2	3	1	2400	13	28	0.09	2	0.94	76	0.11	26	
	1992	830	2	<0.2	0.01	2	3	2	2100	10	31	0.10	2	0.78	51	0.10	37	

sm\16\12\93
tech\table2.djr

TABLE 3. Levels of arsenic (μg/g, dry weight) in feather moss (*Pleurozium schreberi*) near the Atikokan generating station for years before (1981-83) and during (1986-92) operation of the generating station.

Sampling Site[a]	1981	1982	1983	1986	1987	1988	1992
1	7.9	10.0	4.5	2.6	1.0	<0.5	0.5
2	2.8	4.5	2.1	1.8	0.2	<0.5	0.6
3	3.4	5.2	2.2	1.1	0.2	<0.5	0.3
4	14.0	12.0	6.9	5.9	1.5	0.8	0.8
5	0.8	2.0	1.1	0.5	0.5	<0.5	0.2
6	0.6	0.2	0.2	0.3	0.3	<0.5	0.1
7	1.8	3.1	1.8	1.0	0.9	0.6	0.5
8	6.4	8.2	3.2	5.2	0.5	<0.5	0.4
9	1.3	1.5	1.4	0.9	0.5	<0.5	0.3
10	0.5	0.3	0.6	0.3	1.1	<0.5	0.2
11	14.0	8.7	7.2	5.2	1.8	1.0	0.9
12	7.7	2.8	4.2	5.0	1.3	0.6	0.5
13	1.3	1.2	0.5	0.7	0.3	<0.5	0.3
14	0.7	2.2	1.3	1.1	0.2	<0.5	0.2
15			2.4	1.4	0.5	<0.5	0.2
Mean	4.5	4.4	2.6	2.2	0.7	0.5	0.4

[a]See Figure 1 for site locations.

cm/12/15/93
Tech\Atk-tab3.djr

TABLE 4. Average levels of arsenic and iron (μg/g, dry weight) in white pine bark and feather moss (*Pleurozium schreberi*), Atikokan, 1981-1983, 1986-1988 and 1992.

	White pine bark						Feather moss					
	Arsenic			Iron			Arsenic			Iron		
Sampling site[a]	1981-83[b]	1986-88[c]	1992	1981-83[b]	1986-88[c]	1992	1981-83[b]	1986-88[c]	1992	1981-83[b]	1986-88[c]	1992
1	11.9	4.4	2.2	3500	3100	970	7.4	1.4	0.5	5500	3600	810
2	4.5	2.2	0.8	2200	1500	800	3.1	1.8	0.6	1900	1100	1700
3	1.5	0.8	0.6	790	770	530	3.6	0.6	0.3	2000	1000	1100
4	5.6	3.8	3.8	2700	3700	2500	10.9	2.7	0.8	6300	2600	1200
5	0.5	0.3	0.2	430	320	300	1.3	0.5	0.2	1200	850	730
6	0.3	0.3	<0.1	360	180	140	0.4	0.4	0.1	610	640	610
7	0.8	0.7	0.4	360	500	500	2.2	0.8	0.5	1900	1600	1200
8	8.1	1.2	0.3	3400	960	420	5.9	2.1	0.4	3300	1500	1000
9	0.6	0.4	<0.1	350	420	250	1.4	0.6	0.3	1400	1100	1300
10	0.5	0.3	0.9	510	340	350	0.5	0.6	0.2	1400	1300	1400
11	2.9	1.1	0.8	610	480	750	9.9	2.7	0.9	5500	2600	1400
12	5.7	1.5	0.4	2500	1000	350	4.9	2.3	0.5	3800	3900	940
13	0.5	0.4	0.2	330	300	200	1.0	0.5	0.3	1000	1000	1200
14	1.3	0.5	0.5	400	300	270	1.4	0.6	0.2	1100	970	730
15[d]	1.2	0.6		520	530		2.4	0.8	0.2	2500	770	730
Mean	3.2	1.2	0.8	1300	960	600	3.9	1.2	0.4	2700	1800	1100

[a] See Figure 1 for site locations.
[b] Pre-operational surveys.
[c] Operational surveys.
[d] Sampling began in 1983.

jg/12/21/93
air\table4.dr

TABLE 5. Levels of selected elements and pH in three depths of soil, Atikokan, 1992. All elemental values are $\mu g/g$, dry weight, except aluminum, calcium, iron, magnesium, potassium and sulphur, which are in percent, dry weight.

		Al	As	Cd	Ce	Cl[a]	Cr	Cu	F	Fe	Pb	Mg	Mn	Hg	Ni	P	K	Se	Na	S	Tl	Zn	pH
Soil (0-1 cm)	Maximum	0.8	55.0	0.9	1.8	63	34	40	79	3.5	77	0.43	2700	1.80	25	1600	0.21	2.2	150	0.19	720	180	6.7
	Mean	0.4	15.2	0.5	1.0	32	18	9	15	1.4	40	0.16	930	0.34	15	970	0.12	1.2	92	0.14	180	76	4.8
	Minimum	0.2	1.6	<0.2	0.5	6	6	4	6	0.3	7	0.07	76	0.02	7	550	0.00	0.4	50	0.04	63	31	4.1
	Std. Dev.	0.2	15.8	0.3	0.4	17	7	9	20	1.0	16	0.09	760	0.41	5	270	0.05	0.5	25	0.04	160	42	0.7
Soil (1-2 cm)	Maximum	0.8	73.0	1.0	1.6	69	37	42	79	5.1	65	0.45	2800	0.80	25	1400	0.16	2.4	180	0.19	670	190	6.8
	Mean	0.5	16.4	0.5	0.8	37	15	8	15	1.4	40	0.15	660	0.26	12	880	0.11	1.2	100	0.13	210	60	4.6
	Minimum	0.2	1.7	<0.2	0.4	7	4	3	6	0.4	8	0.06	37	0.02	5	500	0	0.4	55	0.04	47	23	3.9
	Std. Dev.	0.2	22.8	0.3	0.3	18	10	10	20	1.4	16	0.10	730	0.18	6	300	0.05	0.5	35	0.05	150	45	0.7
Soil (2-5 cm)	Maximum	2.0	54.0	0.8	1.1	48	35	24	83	3.6	55	0.45	4800	0.41	18	1600	0.19	2.1	210	0.17	1000	160	6.8
	Mean	0.8	10.8	0.4	0.5	23	16	7	15	1.2	28	0.18	550	0.16	11	750	0.09	0.9	120	0.08	390	46	4.4
	Minimum	0.3	1.5	<0.2	0.1	<1	6	2	6	0.3	7	0.05	30	0.01	3	170	0	0.3	45	0.01	65	10	3.7
	Std. Dev.	0.5	14.8	0.3	0.3	12	9	5	20	1.0	12	0.12	1200	0.12	5	410	0.06	0.5	53	0.06	260	46	0.8
Contaminant guidelines[b]			10	3			50	60		3.5	150	1.0	700	0.15	60			2.0		0.10		500	

[a] Extractable chloride.
[b] Applies only to 0-5 cm soil.

cm/12/16/93
Tech\Atk-Tab5.djr

TABLE 6. Annual average concentration of selected parameters in soil, Atikokan, 1981-1992. All results are in $\mu g/g$, dry weight except aluminum, calcium, iron, magnesium, potassium and sulphur, which are in percent, dry weight.

	Al	As	Cd	Ca	Cl	Cr	Cu	F	Fe	Pb	Mg	Mn	Hg	Ni	P	K	Se	Na	S	Ti	Zn	pH
Soil 0-1 cm																						
1981	0.8	30.6	1.8	0.8		38	70	100	2.0	57	0.2	850	0.25	15	720	0.1		88	0.12		82	4.3
1982	0.7	32.2	0.7	1.0		32	32	73	2.2	48	0.2	1100	0.29	16	1200	0.1	1.3	100	0.12	1200	82	4.9
1983	0.7	27.9	0.8	0.9		26	32	60	1.9	55	0.2	890	0.27	14	1200	0.1	2.2	93	0.11	1100	75	4.5
1986	0.5	35.9	0.6	0.8		29	56	12	2.5	52	0.2	540	0.21	16	870	0.1	1.2	100	0.11	2100	70	4.6
1987	0.8	19.1	0.8	0.9	44	19	55	17	1.8	46	0.2	720	0.20	12		0.1	1.5	140	0.11	290	84	4.8
1988	0.7	11.2	0.7	0.7	<100	19	43	14	1.4	43	0.2	620	0.17	12	780	0.1	1.6	130	0.10	400	66	4.9
1992	0.4	15.2	0.5	1.0	32	18	9	15	1.4	40	0.2	930	0.35	15	970	0.1	1.2	92	0.14	180	76	4.9
Soil 1-2 cm																						
1981	1.2	10.2	1.4	0.5		31	29	110	1.6	31	0.3	300	0.13	11	640	0.1		130	0.09		43	3.9
1982	0.8	14.7	0.6	0.8		25	23	81	1.5	41	0.3	700	0.35	12	980	0.1	0.8	120	0.11		62	4.6
1983	1.1	10.2	0.8	0.5		21	26	65	1.0	36	0.2	340	0.19	8	990	0.1	1.2	120	0.09		45	4.4
1986	0.6	18.5	0.4	0.5		21	35	14	1.6	39	0.2	260	0.18	13	720	0.1	0.8	130	0.08	2900	49	4.4
1987	0.9	12.2	0.7	0.7	34	16	47	18	1.2	39	0.2	580	0.17	11		0.1	1.0	170	0.09	380	65	4.6
1988	0.8	11.1	0.9	0.5	<100	19	38	16	1.7	37	0.2	460	0.16	12	720	0.1	1.4	150	0.08	440	56	4.6
1992	0.5	16.4	0.5	0.8	36	15	8	15	1.4	41	0.2	660	0.26	12	880	0.1	1.2	100	0.13	210	60	4.6
Soil 2-5 cm																						
1981	1.4	3.7	1.3	0.3		33	31	150	1.6	11	0.3	140	0.05	17	400	0.1		170	0.05		36	4.1
1982	1.1	9.5	0.6	0.6		28	18	94	1.3	28	0.3	520	0.19	12	700	0.1	0.2	140	0.08		48	4.5
1983	1.1	6.4	0.6	0.5		22	21	56	1.1	21	0.2	160	0.14	7	870	0.1	0.9	160	0.07		31	4.3
1986	0.8	6.3	0.6	0.3		24	26	14	1.1	29	0.2	110	0.11	9	600	<0.1	0.7	130	0.05	3800	35	4.4
1987	0.9	7.9	0.7	0.5	26	17	47	18	1.0	25	0.2	550	0.13	11		0.1	0.8	150	0.07	510	57	4.6
1988	1.3	5.4	0.8	0.4	<100	23	42	16	1.6	33	0.3	400	0.12	14	660	0.1	0.9	170	0.05	740	51	4.5
1992	0.8	10.8	0.4	0.5	23	16	7	15	1.2	28	0.2	550	0.16	11	750	0.1	0.9	120	0.08	390	46	4.4

am/05/01/04
tech\table6.djr

TABLE 7: Precipitation chemistry at four sites in northwestern Ontario, 1982-1984 and 1986-1991.

pH[a] and concentrations[b] (mg/l)

	Quetico Centre[c]							Fernberg Road[d]						
Parameter	1982[e]-1984	1986[e]	1987[e]	1988[e]	1989[e]	1990[f]	1991[f]	1982[e]-1984	1986[e]	1987[e]	1988[e]	1989[e]	1990[e]	1991[e]
pH	5.1	5.2	5.2	5.3	5.5	5.2	4.8	5.2	5.1	5.2	5.6	5.3	5.4	5.2
SO_4	1.0	1.1	1.1	0.9	1.0	1.0	0.8	1.0	0.8	1.2	0.9	1.1	1.1	1.0
NO_3	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.2	0.3	0.3	0.2
NH_4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.4	0.3	0.3	0.4	0.3

Wet deposition rates[b] (kg/ha/year)

SO_4	4.8	5.5	4.7	6.8	5.3	7.3		5.7	3.8	6.0	6.1	7.0	7.5	7.6
NO_3	0.9	1.1	1.1	1.6	1.2	1.8		1.2	0.9	1.1	1.5	1.7	1.8	1.9

jg/12/20/93
air\chemistry.dr

TABLE 7, Cont'd . . . pH[a] and concentrations[b] (mg/l)

Parameter	Lac La Croix[g] 1982[d]-1984	1986[d]	1987[d]	1988[d]	1989	Dawson Township[h,i] 1982[c]-1984	1986[c]	1987[c]	1988[c]	1989[c]	1990[c]
pH	5.0	4.9	5.1	5.3	5.1	5.0	5.2	5.2	5.2	5.1	5.2
SO_4	1.1	1.2	1.2	1.0	1.2	1.2	1.2	1.8	1.4	1.1	1.3
NO_3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.3	0.3
NH_4	0.3	0.2	0.3	0.5	0.3	0.2	0.2	0.7	0.3	0.4	0.3
Wet deposition rates[b] (kg/ha/year)											
SO_4	3.0	5.6	6.8	6.6	7.5	5.4	5.2	11.2	7.9	6.6	
NO_3	0.8	0.9	1.4	1.5	1.7	0.9	1.0	1.9	1.6	1.6	

[a] Arithmetic means.
[b] Volume weighted means.
[c] Event sampling terminated May 27, 1990; cumulative sampling terminated March 19, 1991.
[d] Sampling terminated September 27, 1992.
[e] Based on event data.
[f] Based on cumulative data.
[g] Event sampling terminated March 15, 1984; cumulative sampling terminated March 25, 1990.
[h] Sampling terminated May 17, 1990.
[i] Site moved from Forbes Township to Dawson Township in late 1986.

jg/12/20/93
air\chemistry.dr

DISTRIBUTION LIST

TECHNICAL MEMORANDUM: "Terrestrial and atmospheric deposition studies near the Ontario Hydro thermal generating station, Atikokan, 1992"

Township of Atikokan:
Clerk-Treasurer (Susan Bryk)

Atikokan Library:
Librarian

Ontario Hydro:
Section Head,
Environmental Sciences and Technology,
Environmental Studies and Assessments Department (3 copies).
Chemicals, Fuels and Environment Supervisor,
Atikokan Generating Station (Mr. M. Styczen)

Miyata, T.:
Atikokan

Northwestern Health Unit:
Medical Officer of health, Kenora

Environment Canada:
Regional Director,
Ontario Region,
Environmental Protection Service.

Minnesota Pollution Control Agency:
Regional Director, Duluth
Director, Division of Air Quality

U.S. Environmental Protection Agency, Duluth:
Dr. G. Glass

CKPR/CHFD T.V.:
Thunder Bay Television News

CBQ Radio:
News Department

jg/01/11/94
air\distrib.dr

CKPR 580 Radio:
News Department

CJLB Radio:
News Department

Profile:
Editor

Thunder Bay Post:
Editor

Atikokan Progress:
Editor

Chronicle Journal/Times News:
Editor

Ministry of Northern Development and Mines:
Northern Region and Community Development Branch:
Northern Development Officer, Atikokan
Mine Site Reclamation Section:
Inspector, Kenora

Ministry of Natural Resources:
Regional Director, Boreal West Region
Regional Parks & Planning, Co-ordinator (J. Jackson), Boreal West Region
Area Manager, Seine River/Sapawe Area: Bob McColm
Area Manager, Flanders Area: Dave Elder
Park Superintendent, Quetico Provincial Park: Jay Leather

Ministry of Labour:
District Manager, Occupational Health and Safety (Mr. I. Bauch)

Ministry of Environment and Energy:

Northern Ontario Region:
- District Manager, Thunder Bay
- Regional Laboratory: Trace Contaminants Supervisor

Mid-Ontario Region:
- Chief, Air Resources Unit

Laboratory Services Branch:
- Director
- Manager, Inorganic Trace Contaminants Section
- Supervisor, Vegetation and Soils Unit

Standards Development Branch:
- Manager, Toxicology Support Section

Approvals Branch:
- Supervisor, Industrial Approvals Section

Intergovernmental Relations Office:
- Mr. Ken Richards

Communications Branch:
- Manager, Planning and Programs.

DATE DUE

MOE/AIT/TER/AMWT
Racette, D.J.
Terrestrial and
atmospheric deposition amwt
Studies in the c.1 a aa
vicinity of the Ontario Hydro...

Date | Issued To

MOE/AIT/TER/AMWT
Racette, D.J.
Terrestrial and
atmospheric deposition amwt
Studies in the c.1 a aa
vicinity of the Ontario Hydro...

Environment Ontario
Laboratory Library
125 Resources Rd.
Etobicoke, Ontario M9P 3V6
Canada